EPICS @ GSI and FAIR

Experiment Control System Workshop, April 2023

Peter Zumbruch, GSI/EEL-EKS
2023-April-25

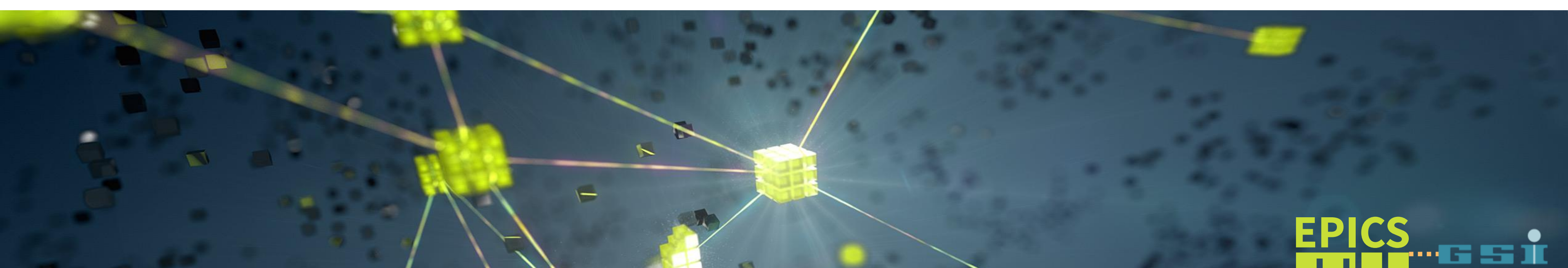
Overview

- Introduction to EPICS

- Using EPICS at
  - HADES
  - R³B
  - PANDA
  - CBM
  - …

(for sure this list is probably incomplete)

INTRODUCTION TO EPICS



WHAT IS EPICS?

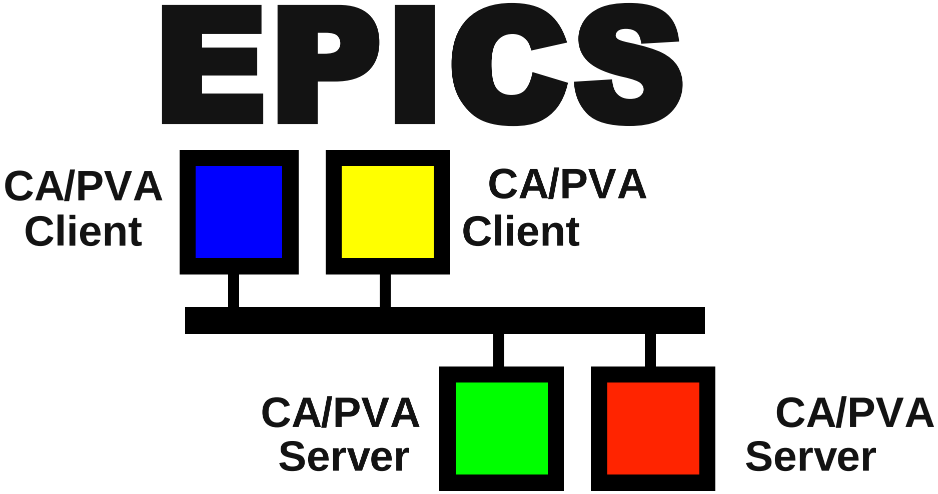
What is EPICS?

(from https://epics-controls.org/about-epics)

- EPICS:
  - *„THE" „Experimental Physics and Industrial Control System"*
  - *eco-system or a set of software tools and applications,*
    - which provide a *software infrastructure* for use in building *distributed control systems* … to operate devices such as Particle Accelerators, *Large Experiments* and major Telescopes. EPICS uses *Client/Server* and *Publish/Subscribe* techniques to communicate between the various computers.
  - Most servers (called I*nput/*O*utput* C*ontrollers* or *IOC*s)
    - perform *real-world I/O* and *local control tasks*,
    - and *publish* this information to clients using robust, EPICS specific network protocols *Channel Access* and *pvAccess*.
    - These protocols are designed for
      - high bandwidth,
      - soft real-time networking applications that EPICS is used for,
      - and is one reason why it can be used to build a control system comprising hundreds of computers.

What is EPICS? (let’s see the old logo…)

- A Collaboration
- A Control System Architecture
  - Network-based “client/server” model (hence the old EPICS logo), incorporating publisher/subcribe methods



For EPICS, *client* and *server* speak of their Channel Access role
i.e. Channel Access Client & Channel Access Server
also PVAccess Client & PVAccess Server

EPICS in short

configuration before compilation!

- Core object: Process Variable
  - uniquely named object (e.g.: `HAD:MDC:LV:ch0:vmon`) containing, e.g. Temperature value
    - + many attributes, EGU, linear conversion, INPut or OUTput, etc.

- An IOC (Input Output Controller) is (nowadays one amidst others) a server process on a network node hosting/configuring datastructures called records, which each represents the PV and its functionality and datatype, e.g. ao, ai, bi, bo, mbbi, mbbo, calc, seq, wave

- Records can connect via their inputs/outputs
  - either to other records, building control loops/chains
    - also across the network to other IOCs
  - devices via more or less generic *device supports, (e.g. asyn, streamDevice, areaDetector)*

- *Together the records and their IOCs build a distributed (soft) real-time database of process variables*

- *clients and servers connect to each other using the Channel Access or the newer PV Access protocol, often via publisher/subscriber methods*

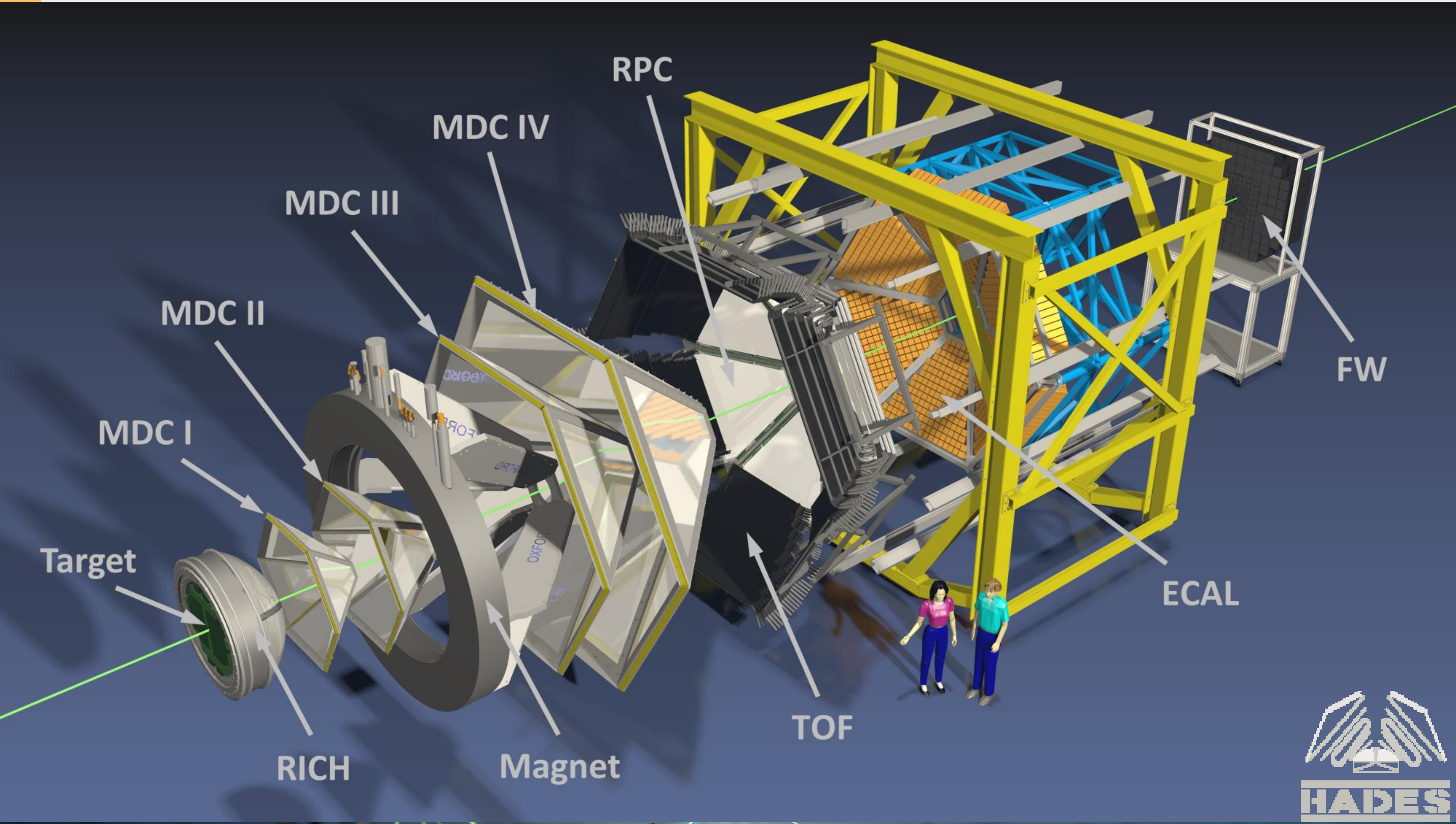
- *Thus Clients can be many applications capable of the above mentioned protocols,*
  - *CLI, GUI, Archiver, many language APIs, e.g. python pyepics, …*

DCS
DETECTOR CONTROL SYSTEM

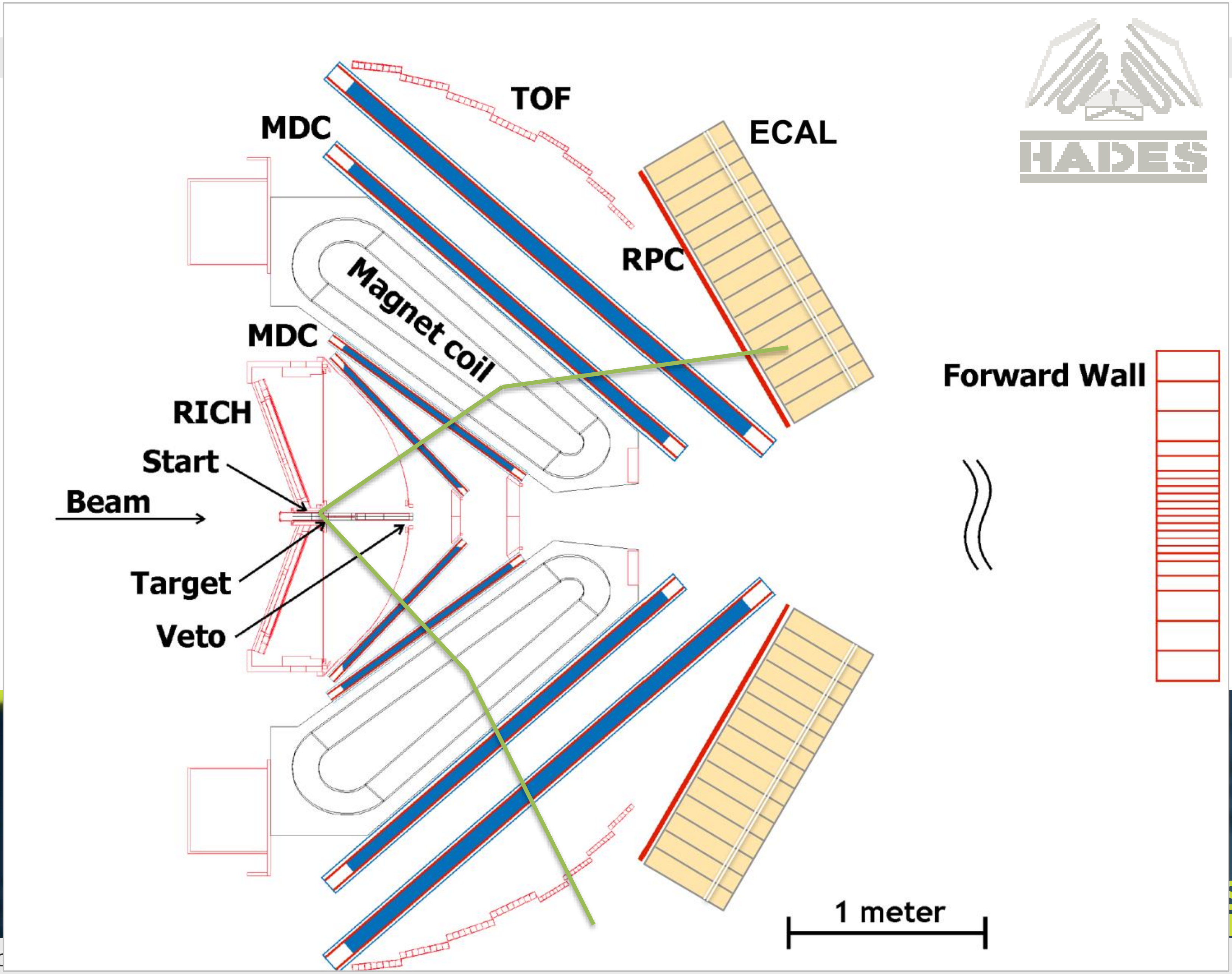
HADES


HADES
D.Fehrenz GSI/FAIR

HADES – High Acceptance DiElectron Spectrometer (setup Ag+Ag)



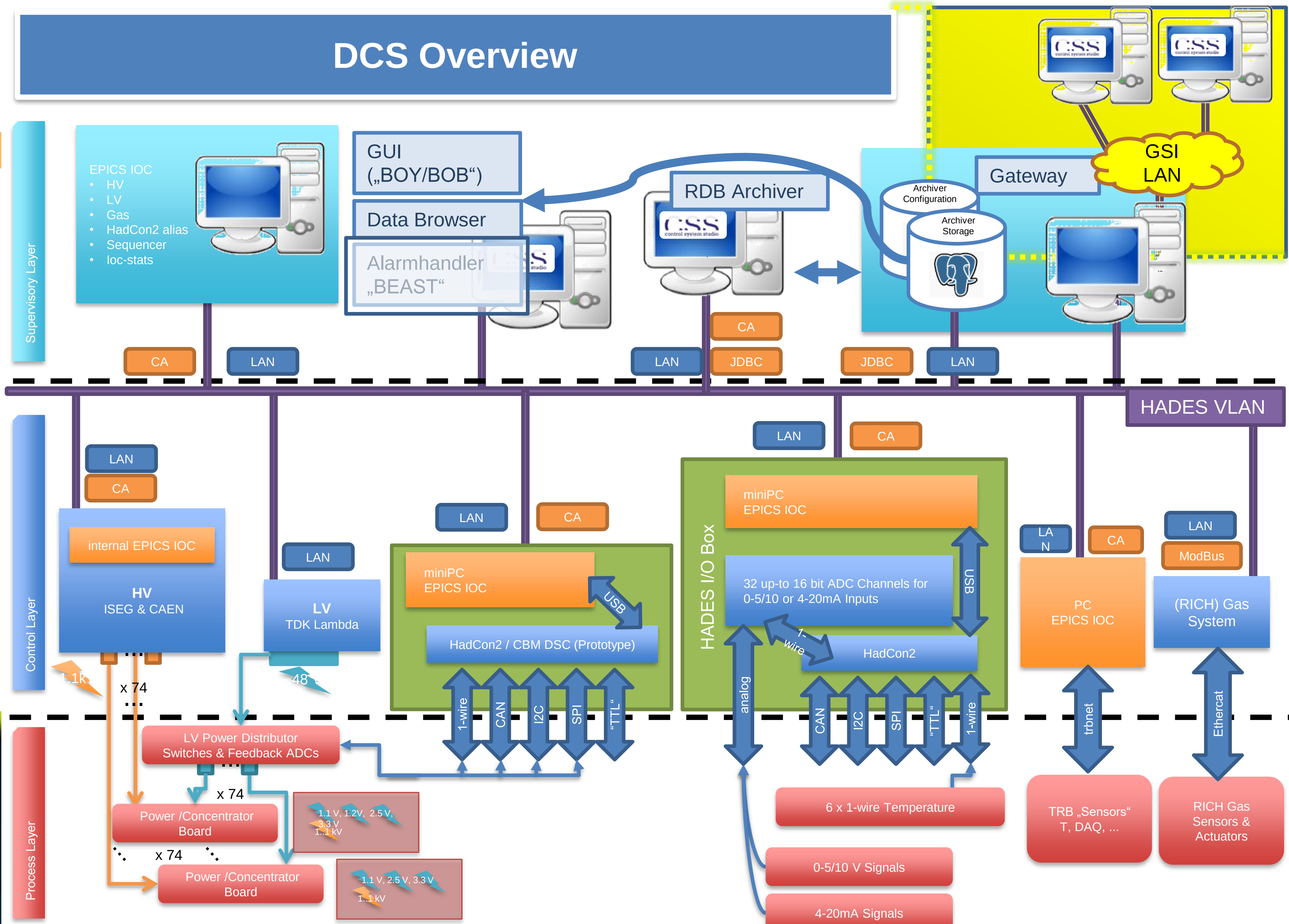
HADES (2) – Vertical cut



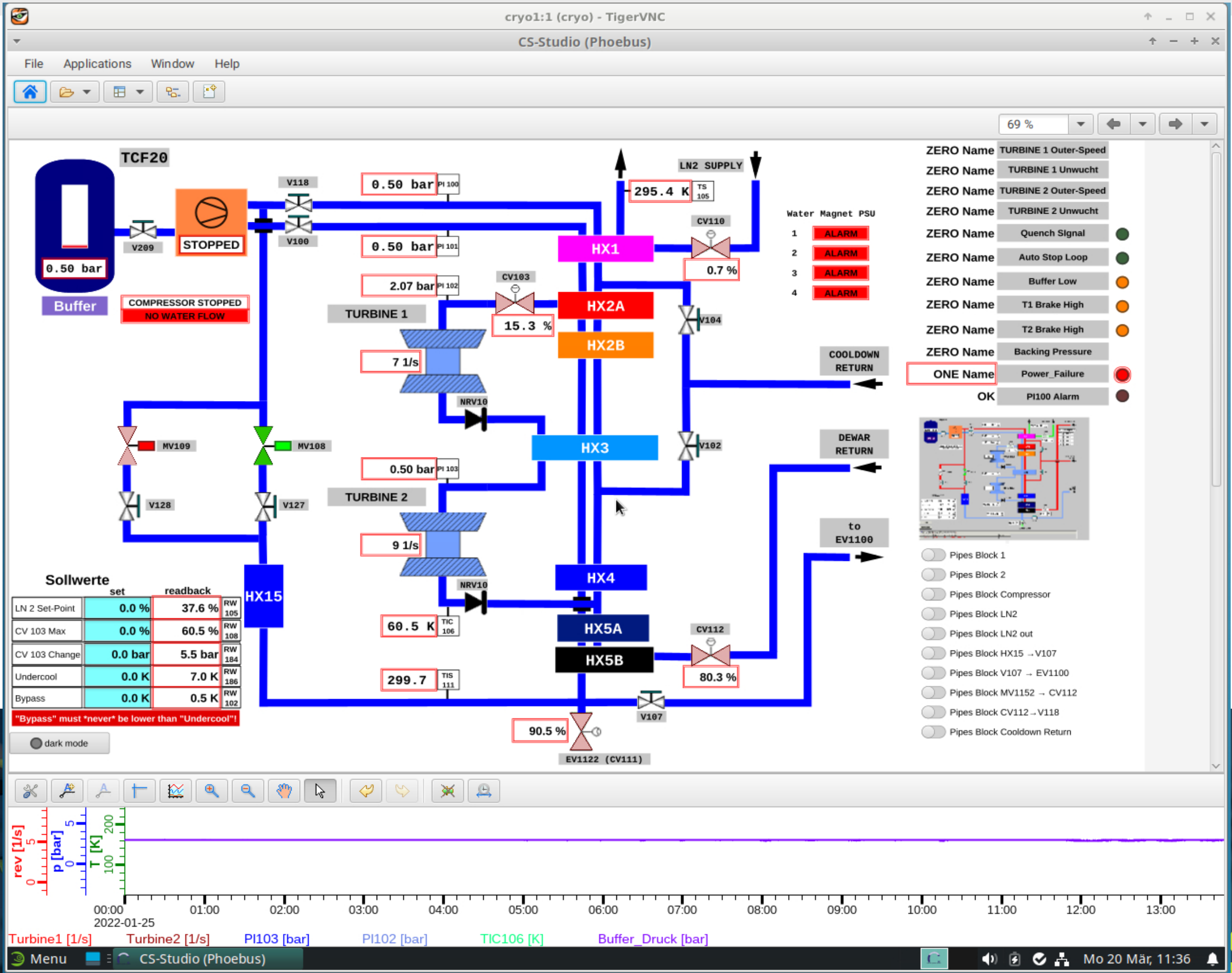
Overview and Status (2022-…)

- HADES control system
  - EPICS system
  - ~ 300,000 Process Variables
    - Temperature, HV, LV, pressures, scales, switches, gas systems, magnet, cryo status, vacuum, beamline
  - ~ 34 compute nodes “IOCs“ (Input Output Controller)
    - 4 central (linux-x86_64)
      - „Main IOC“, FSM Sequencer, HV and LV contro,l **~80k PV**
      - 2 larger: **~13k** and **~90k PV**
    - MCS (old and new) **~10k PV**
    - embedded ISEG IOC **~10kPV**
    - 9 embedded CAEN IOC (HV) in total **~90k PV**
    - 19++ smaller (linux-arm, etrax, linux-x86_64)
      - HadCon1 (etrax FX)
      - HadCon2 + dreamPlug/Raspberry PI
      - Raspberry PI
  - Visualization / GUI client
    - phoebus (all lxhaddcsXY and lxhadeb07)
    - Older CSS 4.4
    - ~~Medm (only lxhaddcs05/06)~~
  - Archiving
    - archiver for ~13,000 Process Variables at 0.1 to 10 Hz
    - CS-Studio based headless RDB Archiver
      - connecting to local containerized PostgreSQL database
  - Involved institutes
    - GSI, Gießen, Krakow

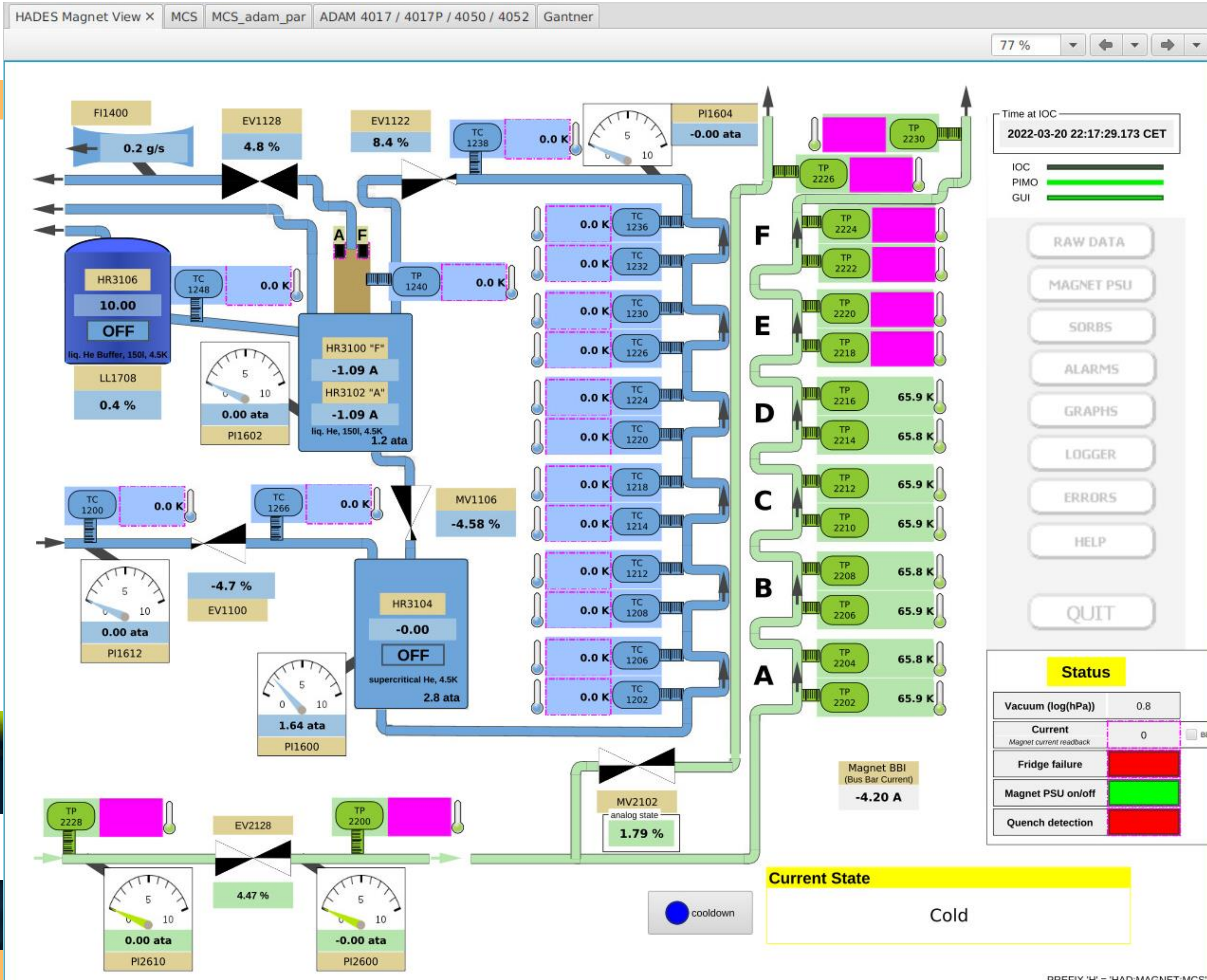
DCS Overview



Operator's VIEW (1) cryo

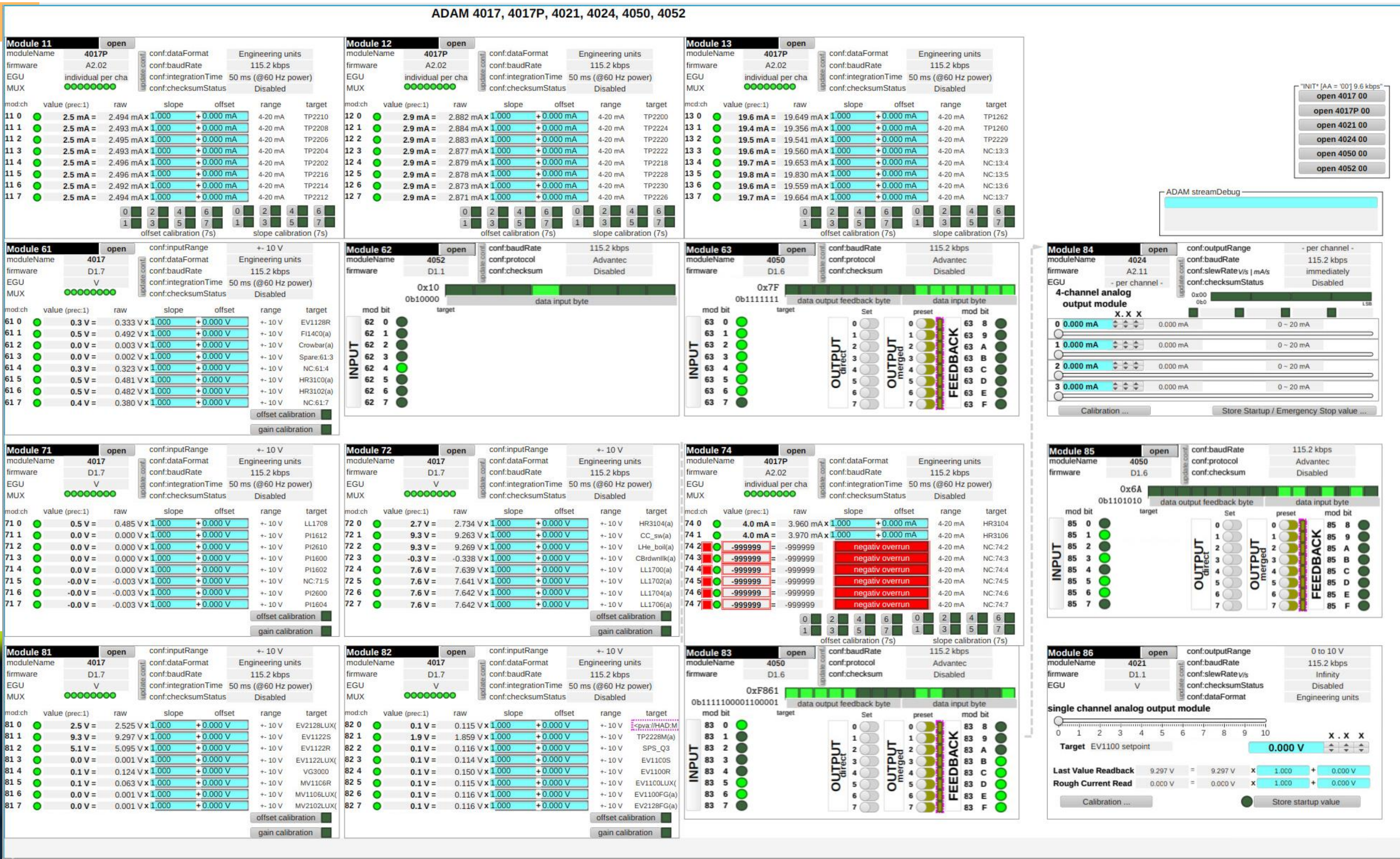


MCS

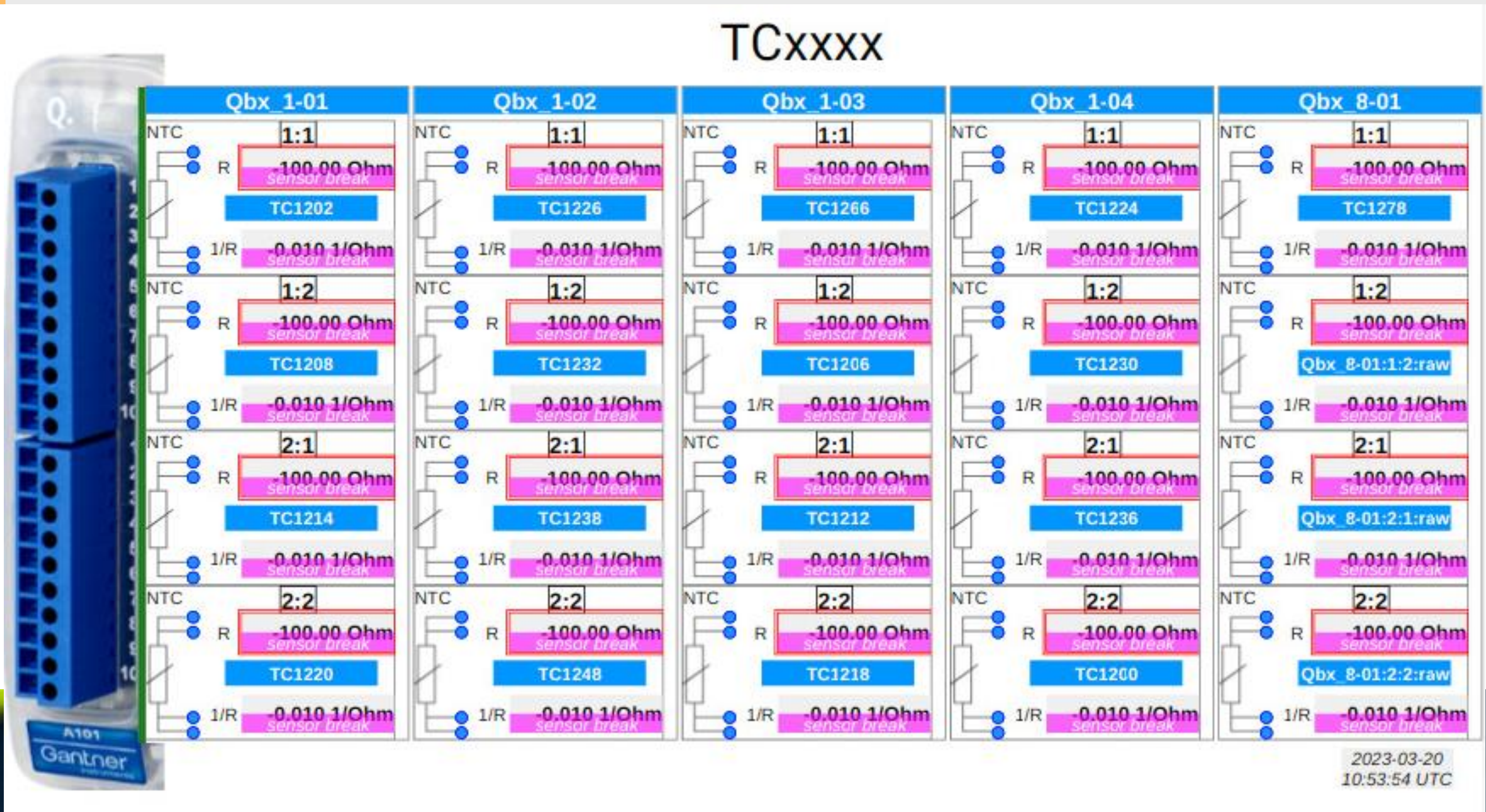


HADES Magnet View
MCS
MCS_adam_par
ADAM 4017 / 4017P / 4050 / 4052
Gantner
77 %
FI1400
0.2 g/s
EV1128
4.8 %
EV1122
8.4 %
TC 1238
0.0 K
PI1604
-0.00 ata
TP 2230
TP 2226
Time at IOC
2022-03-20 22:17:29.173 CET
IOC
PIMO
GUI
HR3106
10.00
OFF
liq. He Buffer, 150l, 4.5K
TC 1248
0.0 K
A
F
TP 1240
0.0 K
HR3100 "F"
-1.09 A
HR3102 "A"
-1.09 A
liq. He, 150l, 4.5K
1.2 ata
LL1708
0.4 %
0.00 ata
PI1602
TC 1236
TC 1232
TC 1230
TC 1226
TC 1224
TC 1220
TC 1218
TC 1214
TC 1212
TC 1208
TC 1206
TC 1202
0.0 K
F
E
D
C
B
A
TP 2224
TP 2222
TP 2220
TP 2218
TP 2216
65.9 K
TP 2214
65.8 K
TP 2212
65.9 K
TP 2210
65.9 K
TP 2208
65.8 K
TP 2206
65.9 K
TP 2204
65.8 K
TP 2202
65.9 K
RAW DATA
MAGNET PSU
SORBS
ALARMS
GRAPHS
LOGGER
ERRORS
HELP
QUIT
TC 1200
0.0 K
TC 1266
0.0 K
MV1106
-4.58 %
-4.7 %
EV1100
0.00 ata
PI1612
HR3104
-0.00
OFF
supercritical He, 4.5K
2.8 ata
1.64 ata
PI1600
Status
Vacuum (log(hPa))
0.8
Current
Magnet current readback
0
BBI
Fridge failure
Magnet PSU on/off
Quench detection
Magnet BBI
(Bus Bar Current)
-4.20 A
MV2102
analog state
1.79 %
TP 2228
EV2128
TP 2200
4.47 %
0.00 ata
PI2610
-0.00 ata
PI2600
cooldown
Current State
Cold
PREFIX 'H' = 'HAD:MAGNET:MCS'

tMCS (technical view)

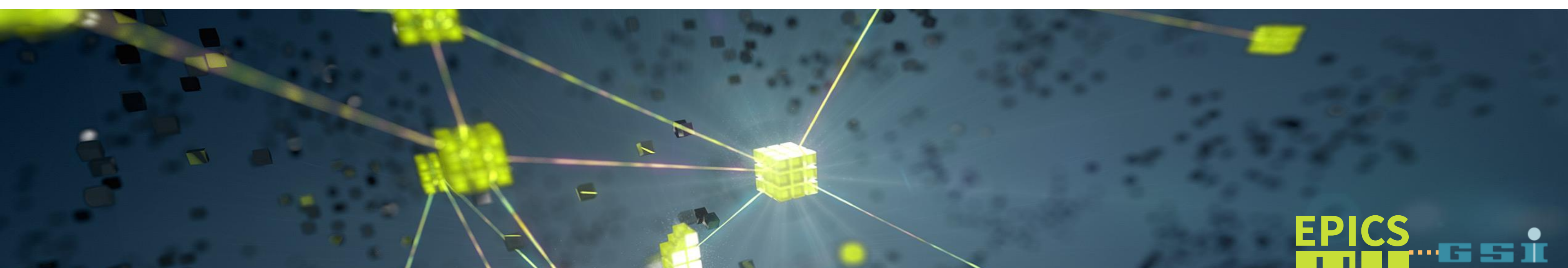


tMCS (technical view) - Gantner



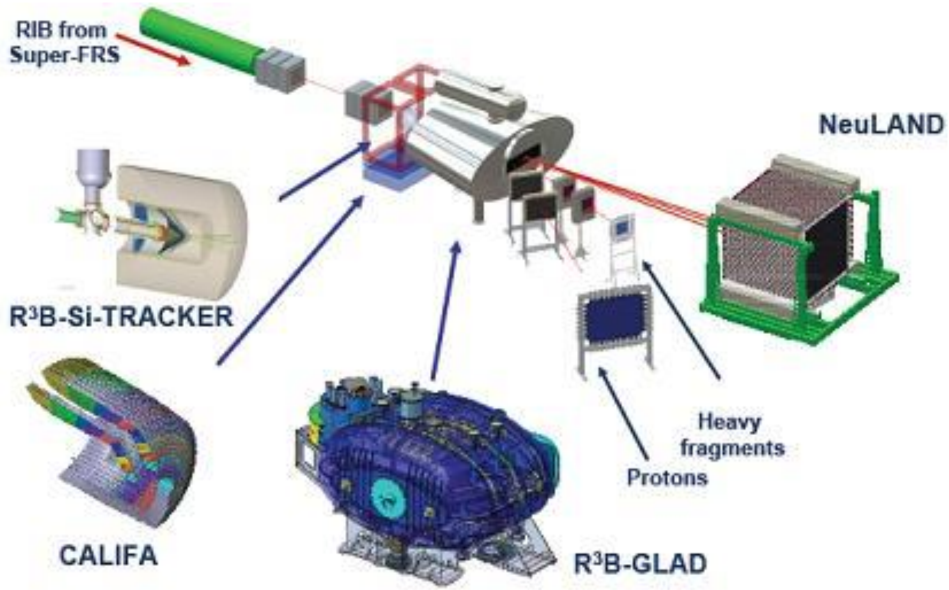
R^3B

Reactions with Relativistic Radioactive Beams



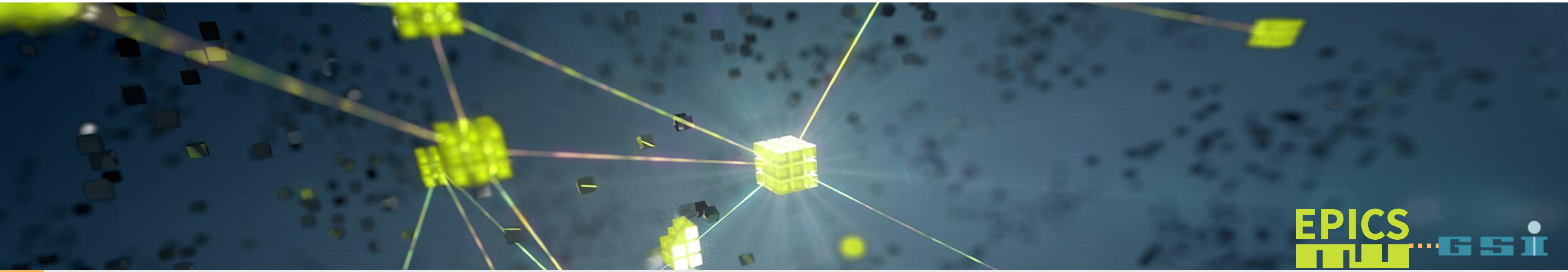

R3B
D.Fehrenz GSI/FAIR

R3B



The R3B (Reactions with Relativistic Radioactive Beams) setup at FAIR will serve the investigation of nuclear reactions with exotic nuclei far from stability. In this approach the nuclei typically have velocities of several 10th of the speed of light. Due to the expected low production rates of the most exotic nuclei that can be reached, a high efficiency is necessary in this experiment. Reaction products, that is particles like protons and neutrons, as well as gamma radiation, will be detected as exhaustive as possible by a complex detector system.

http://www.fair-nustar.de/en/experiments/r3b-eng.html

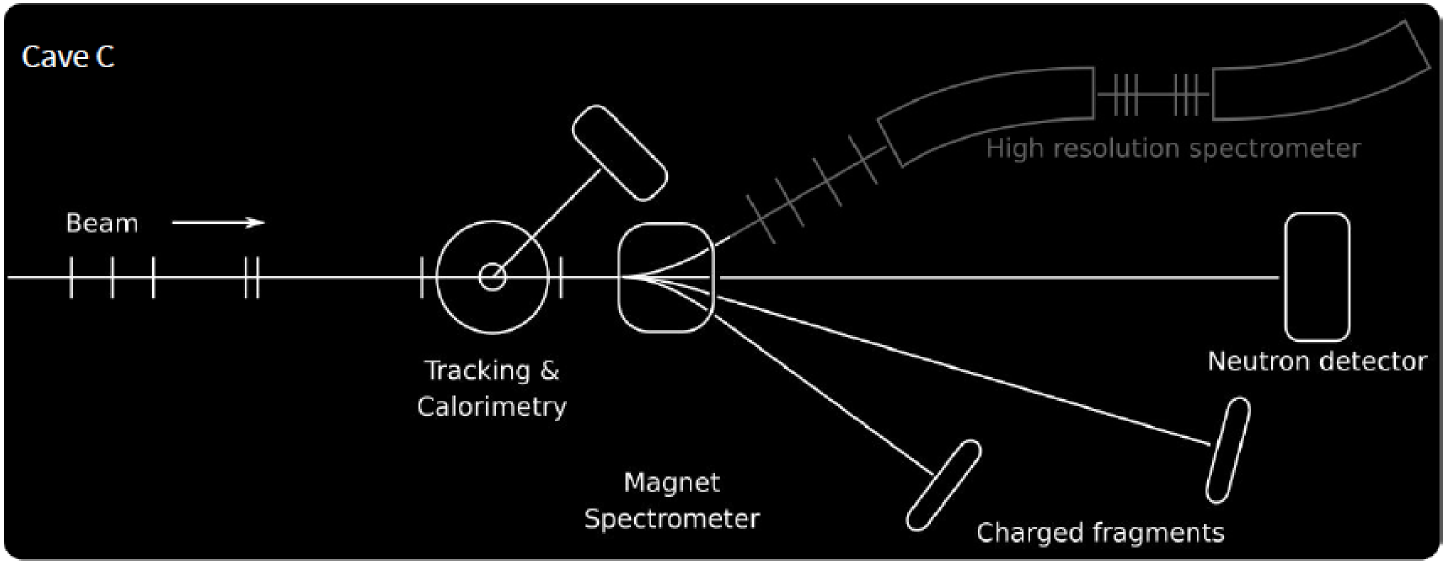


courtesy to B.Loeher, controls coordination

The R3B setup

Reactions with relativistic beams in inverse kinematics

- fixed target experiment, allows high-resolution kinematically complete measurements
- tracking of incoming beam & outgoing fragments (neutrons, light and heavy charged fragments)



courtesy to B.Loeher, controls coordination

The R3B setup - Under control

Scope

- Goal is to control / monitor as much as needed for remote operation, minimize access to Cave C
- Parameters under control / monitoring:
    - Detector front-end cards
    - High / Low voltage power supplies
    - Power distribution units / power strips
    - VME / NIM crates
    - Motor controllers
    - Pressure gauges
    - Gas systems
    - Temperatures
    - Scopes
    - GSI FESA Accelerator parameters
    - R3B DAQ
    - some more I forgot…
- **Today**: Bits and pieces that have solved some of our problems

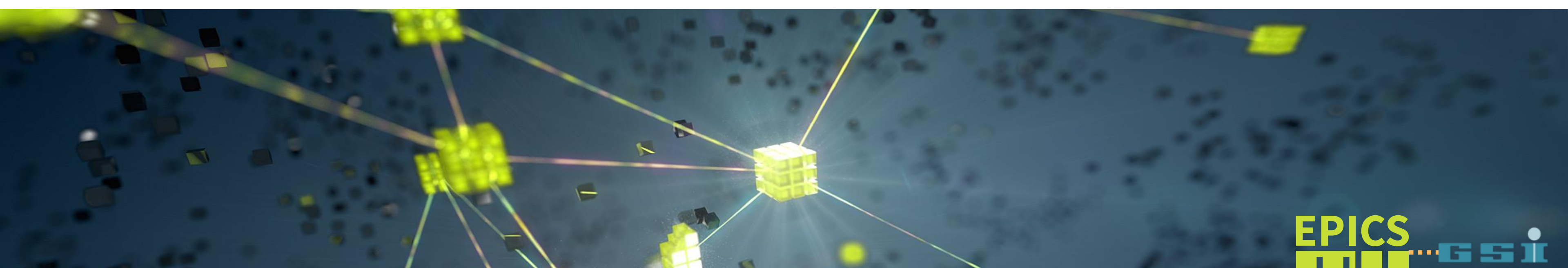
PANDA

transparencies taken from 2018-06-20

$\overline{\text{P}}$ANDA Detector Control System

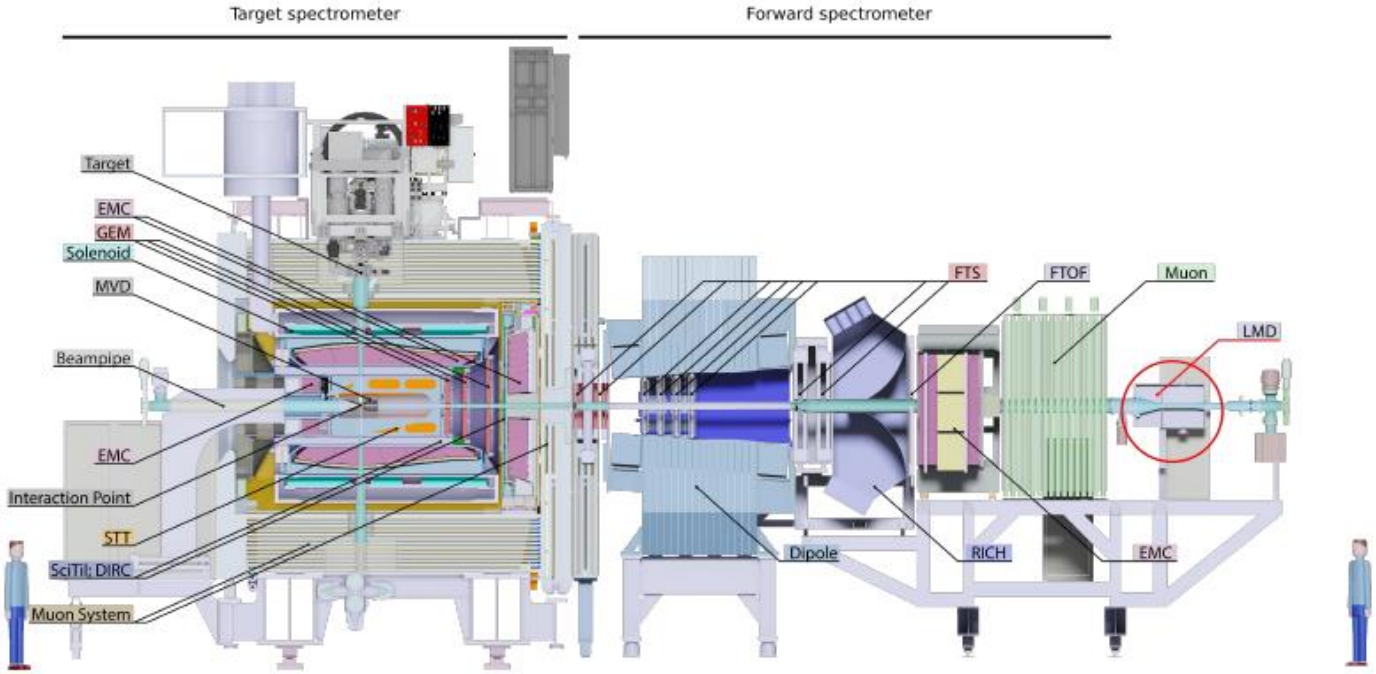
Joint CBM/PANDA DCS Workshop

Florian Feldbauer




PANDA
D.Fehrenz GSI/FAIR

The $\overline{\text{P}}$ANDA Detector



$\overline{\text{P}}$ANDA physics program:

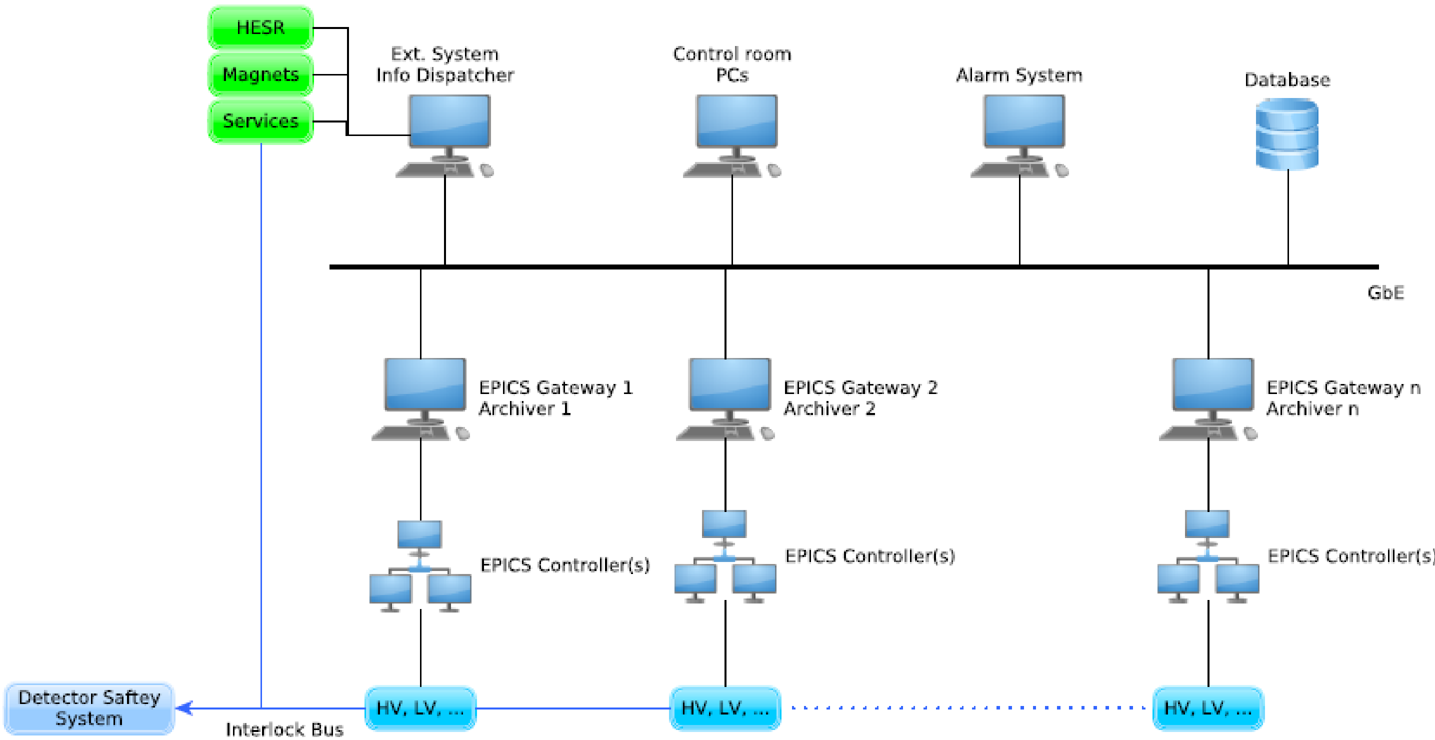
- Hadron spectroscopy
- Hadron structure
- Hadrons in medium
- Hypernuclear physics

DCS Overview

Supervisory Layer

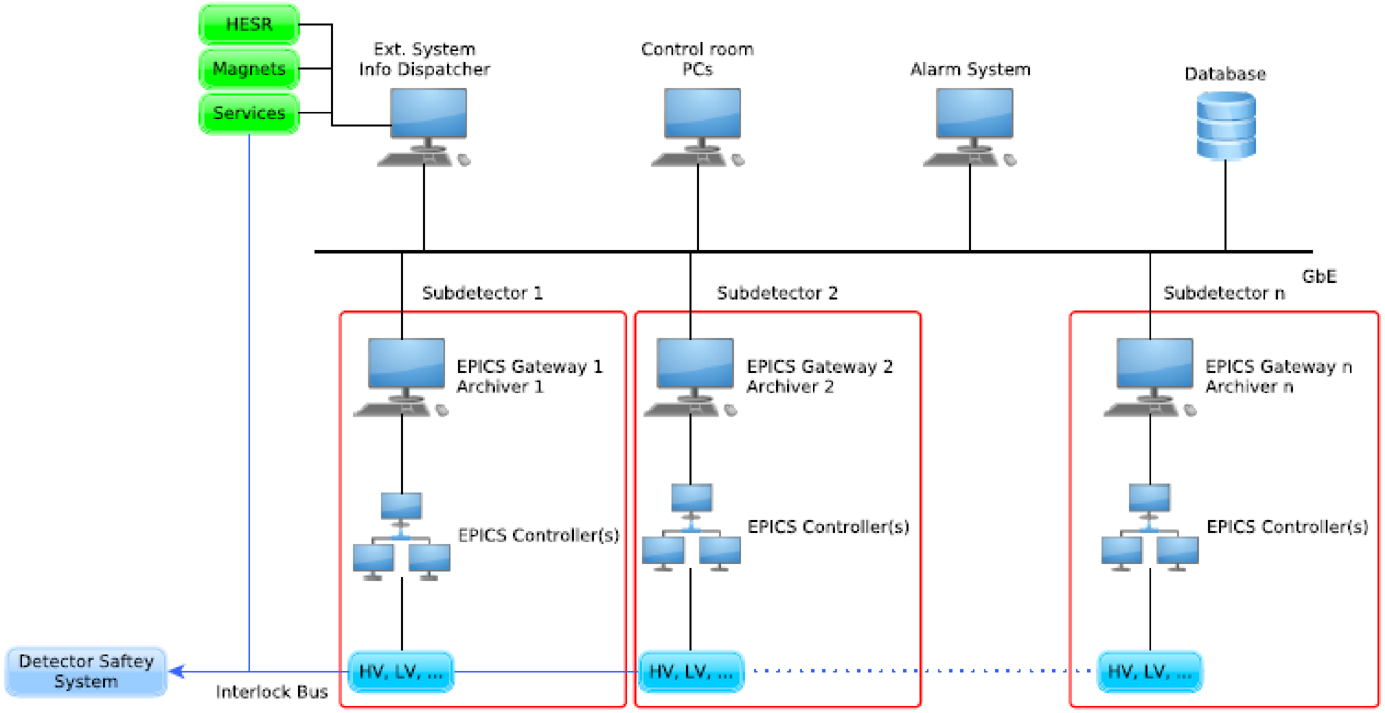
Controls Layer

Process Layer



3 F. Feldbauer PANDA DCS RUHR UNIVERSITÄT BOCHUM RUB

DCS Overview

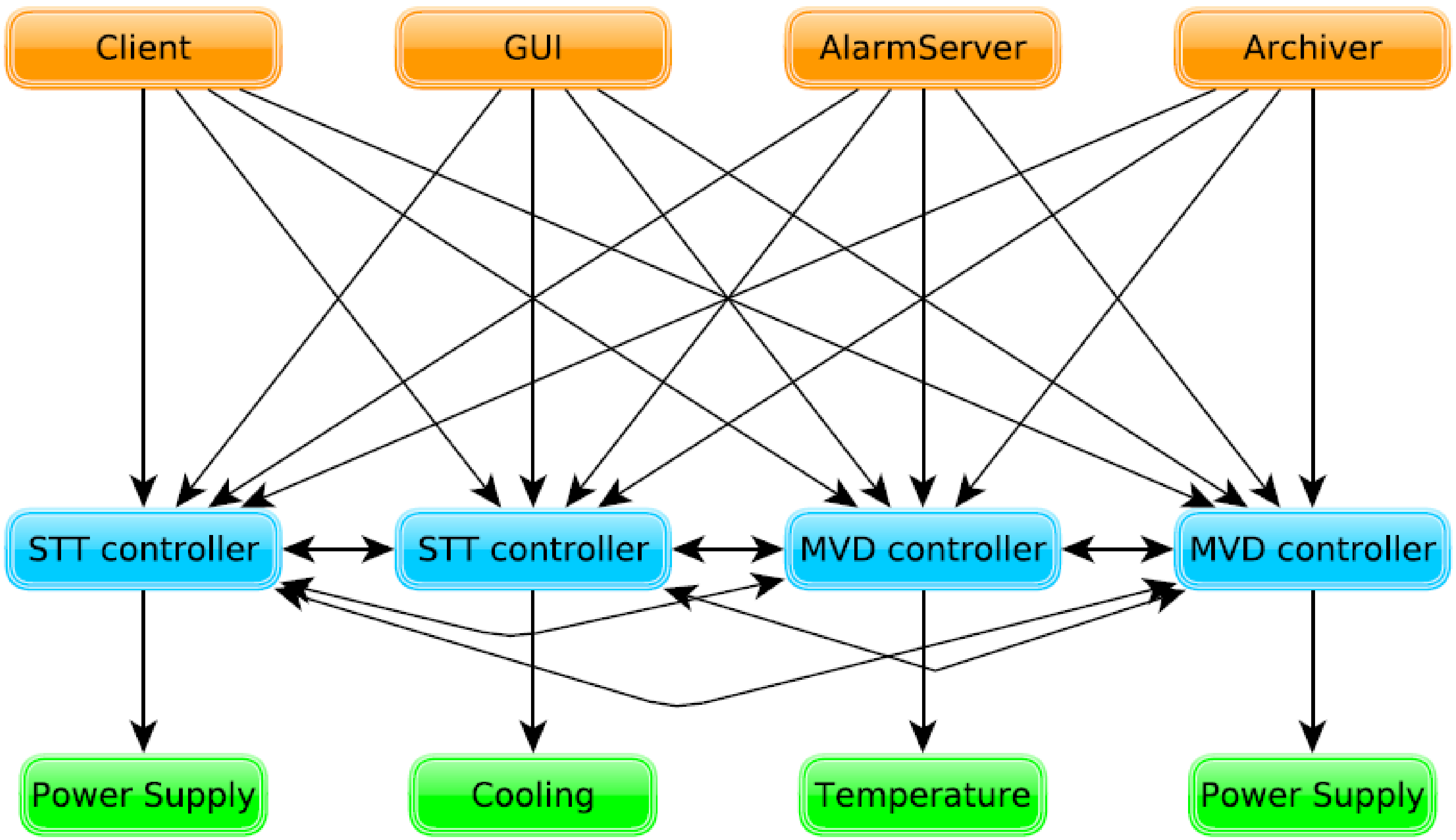


EPICS - **E**xperimental **P**hysics and **I**ndustrial **C**ontrol **S**ystem

- Decentralized architecture
- Freely scalable
- Allows "partitioning" $\Rightarrow$ each subdetector has its own DCS

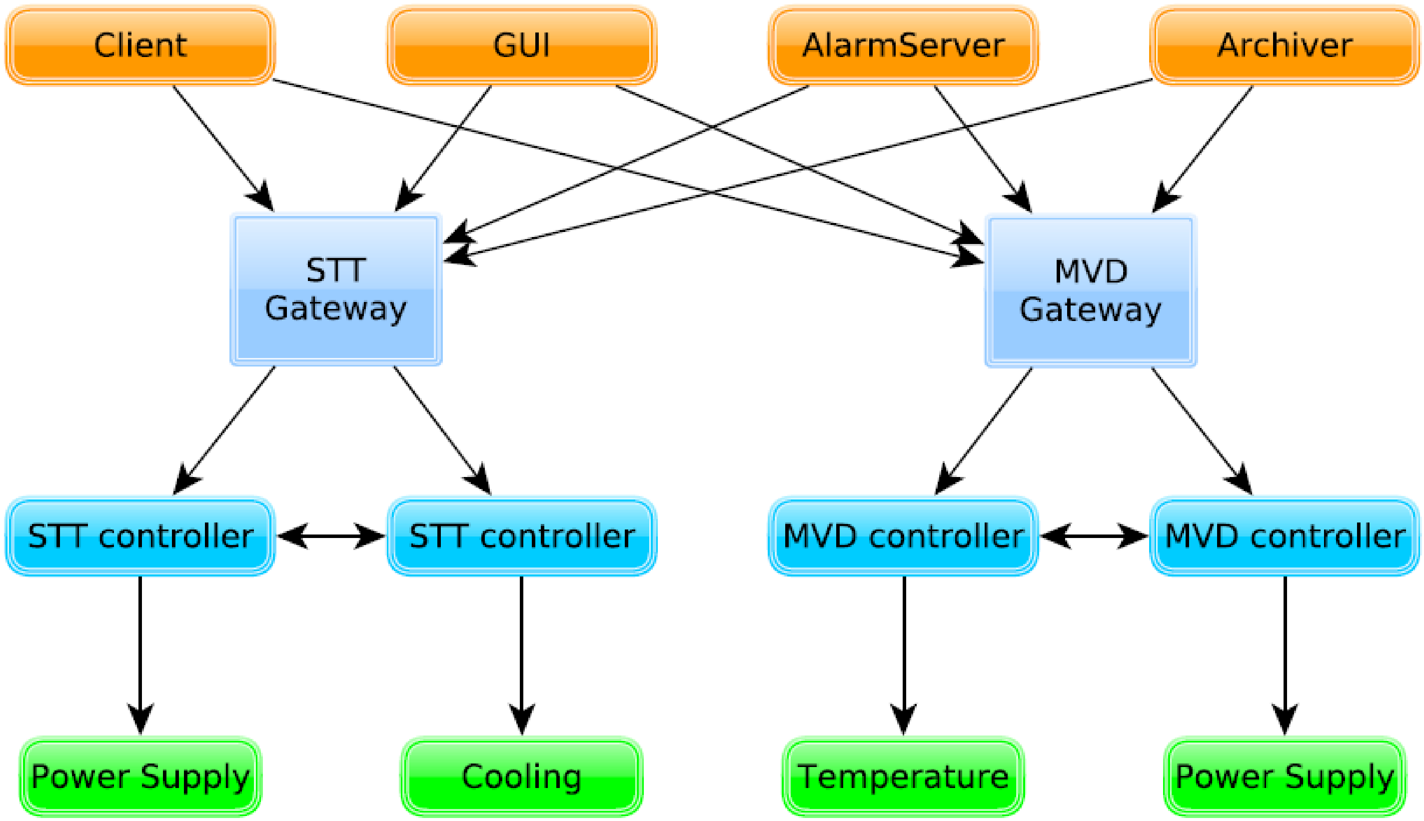
EPICS Communication Protocol

Each Client is connected to each Server
Arrows indicate direction of data queries



EPICS Communication Protocol

Using gateways to separate subdetectors from global DCS
Uni-directional connection!



CBM

Compressed Baryonic Matter


CBM
D.Fehrenz GSI/FAIR

CBM

Next talk by Marcel Bajdel

… no details

- further known EPICS setups at APPA
  - ask e.g. Raul Cantemir, thesis from GSI
  - gamma-ray setups, HV control

Summary

- What is EPICS
- several large scale, and scalable experiments use EPICS as their DCS
  - partly also as ECS (experiment control system) including data acquisition

- Due to its distributed ansatz it is well scalable
  - From small size table top to many 100,000 PVs

- EPICS‘ large community (>100 institutes worldwide, big long-term players ITER, ESS) provides many interfaces to devices, other languages, and other DCSs

more about EPICS

- https://epics-controls.org
- currently in parallel EPICS Spring Meeting
  - https://indico.fnal.gov/event/58280/
  - being recorded and after ~1 week available via the website
- mailing list „tech-talk“

THANK YOU

and:

F.Feldbauer
B.Loeher
M.Bajdel
HADES, CBM, R3B, PANDA